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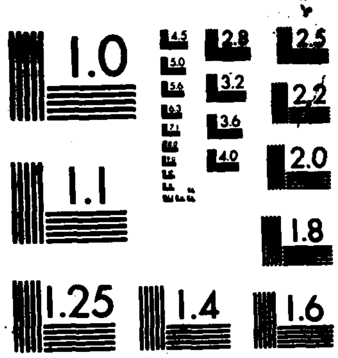

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TECHNICAL REPORT RD-RE-86-3

EFFECTS OF INTERLACE, TILT AND SCALE FACTORS IN AN INCOHERENT REAL-TIME ELECTRO-OPTICAL IMAGE CORRELATOR

John L. Johnson
Research Directorate
Research, Development, and Engineering Center

AUGUST 1986

U.S. ARMY MISSILE COMMAND
Redstone Arsenal, Alabama 35898-5000

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9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER

8c. ADDRESS (*City, State, and ZIP Code*)

10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO

11. TITLE (*Include Security Classification*)
Effects of Interlace, Tilt and Scale Factors in an Incoherent Real-Time Electro-Optical Image Correlator

12. PERSONAL AUTHOR(S)
John L. Johnson

13a. TYPE OF REPORT
Technical

13b. TIME COVERED
FROM ________ TO ________

14. DATE OF REPORT (*Year, Month, Day*)
86 AUG

15. PAGE COUNT
11

16. SUPPLEMENTARY NOTATION

17. COSATI CODES

FIELD	GROUP	SUB-GROUP

18. SUBJECT TERMS (*Continue on reverse if necessary and identify by block number*)
Incoherent correlator
Optical correlator
Real-time correlator
Interlace scan
Integrating CCD camera

19. ABSTRACT (*Continue on reverse if necessary and identify by block number*)
The performance of an incoherent real-time optical correlator with respect to residual tilt and scale misalignment is discussed. The correlator uses CCD video data input streams and produces a real-time output in the form of a standard television video frame. The interlaced fields of the inputs and outputs are discussed and their proper use is described.

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UNCLASSIFIED

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I. INTRODUCTION

The purpose of this report is to assess the effects of several factors on the performance of the incoherent electro-optical real time correlator system. This system is based on the design proposed in references one and two by D. Psaltis. It uses an acousto-optic bragg cell to modulate a real-time video input image with a reference image which is produced by a special parallel readout high speed memory and a custom LED diode array. The correlation is read out with a CCD video camera which has been modified to perform one of the two required convolution integrals.

The factors discussed here are:

1. The interlaced input video data stream.

2. Tilt misalignments of the anamorphic optical system and residual scale differences and lateral displacement errors.

The principal elements of the system are indicated in Figure 1. The optical system O_1 transforms the M-element linear LED array into a M-line image in the AO cell. The optical system O_2 transforms the area A_1 into a rescaled area A_2 on the output CCD 2. The width D_1 corresponds to the length of the input video line from CCD 1 just as it begins to travel across the AO cell window. The detailed operation of this system is described in references 1 and 2.

II. INTERLACE EFFECTS

Consider the the output of CCD #2. It consists of N lines and is one full frame of video. It is sent to an output video monitor which writes the first N/2 lines as field #1 and the second N/2 lines as field #2. Suppose the CCD #2 is a single correlation peak. Then the monitor fields are:

Field #1: The first N/2 lines stretched 2X vertically.

Field #2. The second N/2 lines stretched 2X vertically.

The interlaced result will be the original image cut in two, the halves stretched and overlaid on each other. This is sketched in Figure 2.

In order to avoid this, we need instead, to have a field #1/field #2 flattened dual correlation peak image out of CCD #2. This is sketched in Figure 3. How can this be obtained? What we know is that the system of Figure 1 will produce correlation peaks everywhere the AO video input matches the reference image. Thus, if the video from CCD #1 is a standard field #1/field #2 sequence, then a single target scene presented to CCD #1 is converted automatically to a doubled and flattened dual target "image" as it is received by the AO cell. This is exactly the input image desired. However, the decomposition by CCD #1 of the input scene into two fields destroys half the vertical resolution. The only way to avoid this is to use a completely uninterlaced system, which is expensive and difficult in practice.

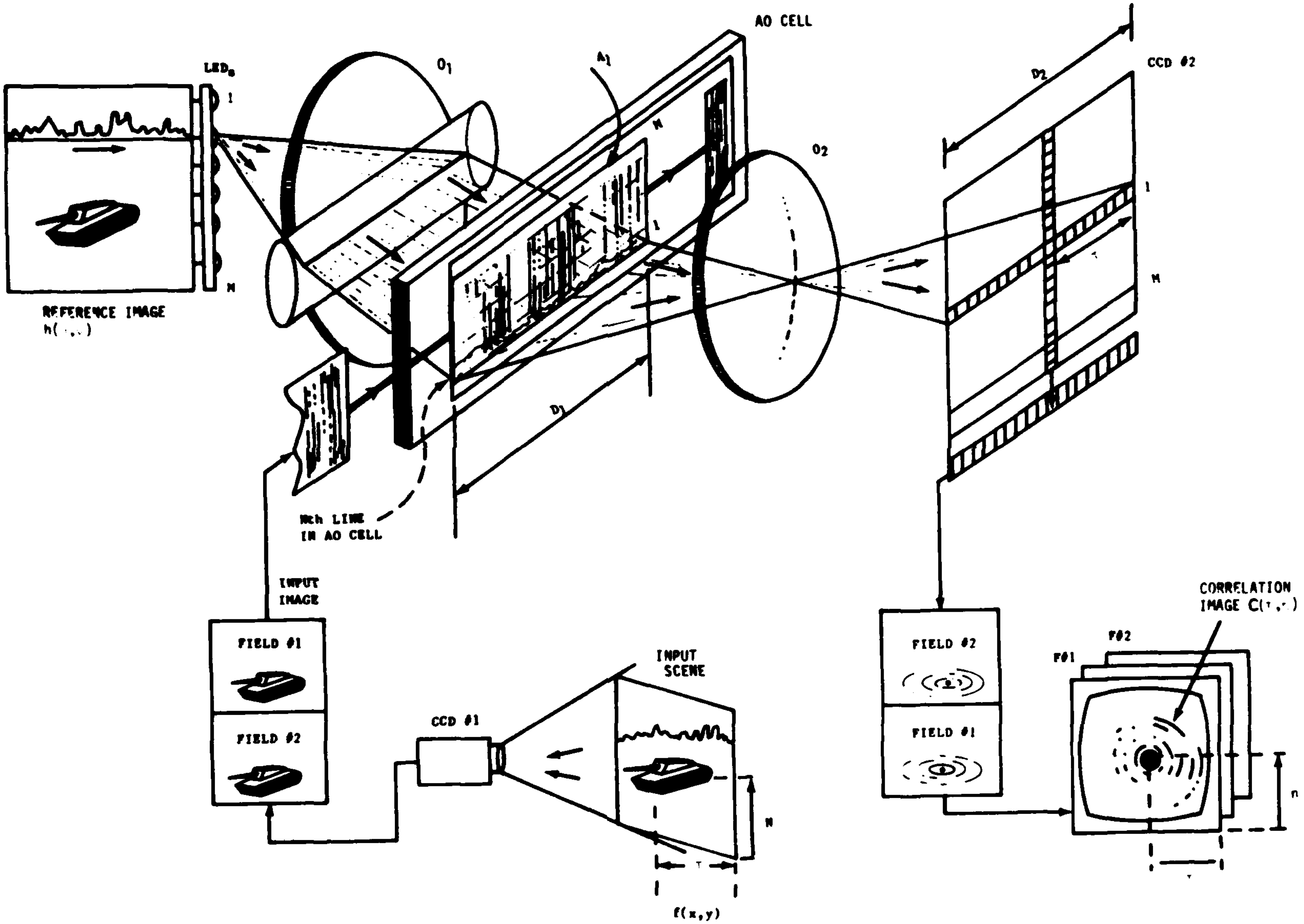

Figure 1. Correlator functions.

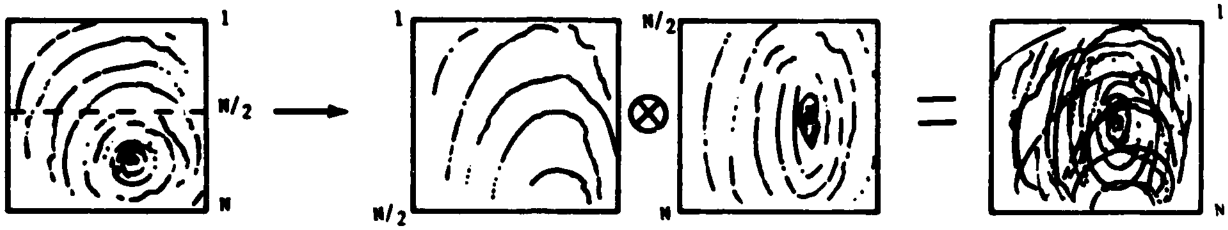

Figure 2. Uninterlaced input is scrambled by interlaced output. Reference image has full resolution.

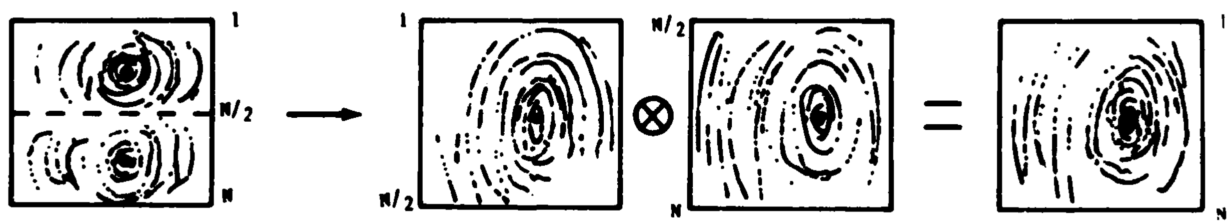

Figure 3. Good output with fully interlaced system. Reference image has half the vertical resolution.

Thus, the use of interlace mode is appropriate for the correlator if the reference image is one field rather than one frame. The slight difference between two fields will produce an equally slight decorrelation in one field of the output; however, the other field will always be exact and thus the system should still operate satisfactorily.

III. TILT AND SCALE EFFECTS

The effects of tilt and scale changes can all be accounted for as equivalent operations on the reference image. As long as the amount of change is within the established limits of standard image correlators, usually several percent of variation, these factors will not preclude normal operation of the real-time correlator. The correlator is invariant under lateral translation of the images, so this factor should have no effect.

Mathematically, the correlation image is

$$C(\tau,n) \;\alpha\; \sum_{k=n-m+1}^{n} \int_{T_1}^{T_1+T_2} f(t-\tau,k)h(t,m+k-n)dt$$

and tilt and scales changes are equivalent to the transformation

$$h(u,v) \rightarrow h(u', v')$$

where

$$u' = \alpha\,(u \cos\,\theta + v \sin\,\theta)$$

$$v' = \beta\,(v \cos\,\theta - u \sin\,\theta)$$

are scaled and rotated coordinates. The scale factors (α, β) thus should be within a few percent of unity and the angular rotation θ within approximately $\pm\,5^0$.

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1. Psaltis, D., Opt. Eng Vol 23, No. 1, Jan/Feb 1984, p. 12.
2. Psaltis, D., Proc. IEEE, Vol 72, No. 7, July 1984, p. 962.

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Department of Defense
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